United States Patent [19]

Fromentin

[11] **Patent Number: 4,749,828**

[45] **Date of Patent: Jun. 7, 1988**

[54] **BIDIRECTIONAL ACCELEROMETRIC ISOLATOR**

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[21] Appl. No.: **900,786**

[22] Filed: **Aug. 27, 1986**

[30] **Foreign Application Priority Data**

Aug. 27, 1985 [FR] France 85 12782

[51] **Int. Cl.**[4] **H01H 35/14**

[52] **U.S. Cl.** **200/61.53**

[58] **Field of Search** .... 200/61.45 R, 61.53; 180/282; 340/669

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,022,393	2/1962	Weaver	200/61.45 R
3,096,411	7/1963	Chabrek et al.	200/61.53
3,859,650	1/1975	Prachar	200/61.53 X
3,889,130	6/1975	Breed	200/61.53 X
4,266,107	5/1981	Abbin, Jr. et al.	200/61.53
4,345,124	8/1982	Abbin, Jr. et al.	200/61.53
4,574,168	3/1986	Devaney	200/61.53

FOREIGN PATENT DOCUMENTS

2138288 1/1973 France .

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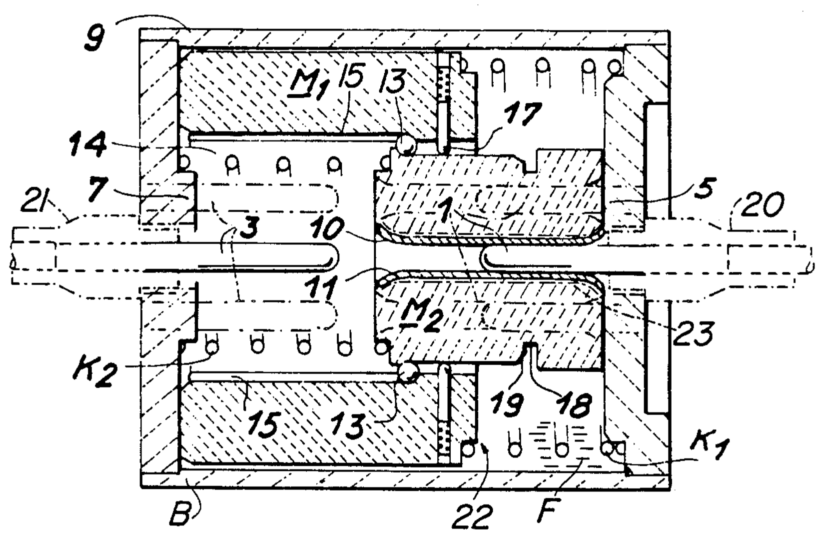
[57] **ABSTRACT**

A bidirectional accelerometric isolator comprises a box, at least one pair of elelctric contact pins facing one another in the box and an arrangement for reversing the electrical continuity state of the pins in the box. This arrangement includes a first mass sensitive to an acceleration of the box in a first direction in order to move to an arming position in which the mass is automatically rendered integral by a lock with a second mass, the first and second joined masses then being sensitive to an acceleration of the box in a second direction which is opposite to the first so that they move into an actuating position reversing the electrical continuity state of said pins. The isloator has particular application to fields requiring the making or breaking of d.c. or pulse-type currents, particularly those of a very high level, following two successive accelerations of the isolator in opposite directions, such as in aerospace, robotics and particularly in constraining environments.

8 Claims, 1 Drawing Sheet



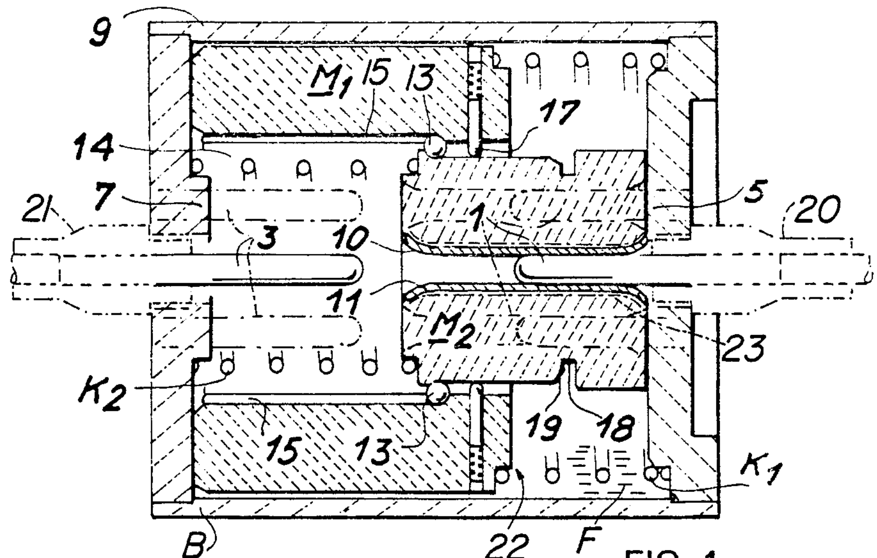


FIG. 1

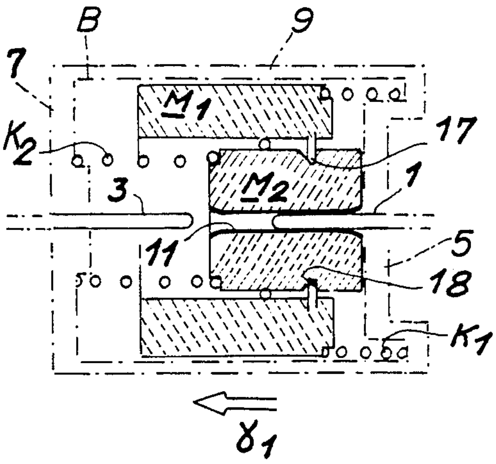


FIG. 2a

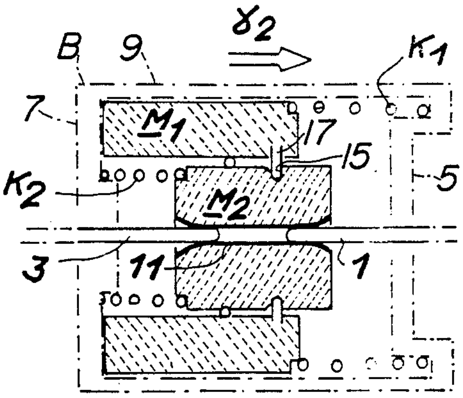


FIG. 2b

BIDIRECTIONAL ACCELEROMETRIC ISOLATOR

BACKGROUND OF THE INVENTION

The present invention relates to a bidirectional accelerometric isolator requiring two accelerations in opposite directions in order to be operative.

The invention applies to widely varying fields, such as aerospace, where an acceleration and a deceleration may result from a trajectory in the atmosphere, or robotics where machines use reciprocating movements. It can also apply to the security field, when it is necessary to make or break an electric contact, e.g. in the case of a mechanical traffic incident or accident (road, railway, air), as well as in constraining environments requiring the making or breaking of d.c. or pulse-type currents, particularly of a very high level.

SUMMARY OF THE INVENTION

The invention relates to a bidirectional accelerometric isolator making it possible to make or break one or more electric contacts following the application of two successive accelerations in opposite directions.

More specifically, the present invention relates to an accelerometric isolator, wherein it comprises a box, at least one pair of electrical contact pins facing each other inside said box and mechanical means for reversing the electrical continuity state between the said pins, said means comprising a first mass located in the box and sensitive to one acceleration of the box in a first direction for moving into an arming position in which it is automatically made integral, by locking means with a second mass located in the box, the first and second masses being joined by said locking means and being sensitive to an acceleration of the box in a second direction opposite to the first direction in order to move into an actuating position, the electrical continuity state between said pins being reversed by the displacement of the second mass into the actuating position.

According to an embodiment of the accelerometric isolator, the box comprises two end walls in which are mounted the electric pins which are insulated from said end walls. The first mass is normally biased toward one of the walls by first elastic means and the second mass is normally biased toward the other wall by second elastic means.

According to another embodiment of the accelerometric isolator, the second mass has a hole, e.g. a bore, on the axis of the pair of pins whose walls electrically contact said pins. Said walls are electrically insulated from the second mass.

According to another embodiment of the accelerometric isolator, the first mass surrounds the second mass and the locking means comprise at least one spring-loaded lug able to project radially from one of the masses to penetrate a groove formed in the other mass, when the first mass is in the arming position.

According to another embodiment of the accelerometric isolator, the groove has a sloping edge permitting an unlocking of the two masses.

According to a preferred embodiment of the accelerometric isolator, sliding means are located between the two masses. These sliding means are e.g. constituted by at least three balls or three rollers located in three circumferentially spaced grooves formed in one of the masses.

Advantageously, the box contains a fluid for damping the movements of the masses.

According to a constructional variant of the accelerometric isolator, the isolator comprises several pairs of parallel electric contact pins, the second mass having at the most one hole per pair of pins.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is described in greater detail hereinafter relative to non-limitative embodiments and the attached drawings, wherein show:

FIG. 1, diagrammatically and in longitudinal section, an embodiment of the bidirectional accelerometric isolator in the inoperative state according to the invention.

FIGS. *2a* and *2b*, diagrammatically, the bidirectional accelerometric isolator of FIG. 1 respectively when subject to a first acceleration in a first direction and when subject to a second acceleration in the reverse direction.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The accelerometric isolator according to the invention, as shown in FIGS. 1 to 2*b* comprises a box B constituted by two parallel, planar end walls **5**, **7**, connected by a cylindrical wall **9**. Each of the end walls **5**, **7** is traversed by one or several aligned electric contact pins **1**, **3**. Preferably, these pins **1**, **3** are electrically insulated from walls **5**, **7** by insulators shown in phantom at **20**, **21**, respectively, in FIG. 1. Continuous and dot-dash lines are used to indicate in FIG. 1 the cases where each wall is traversed by one and two pins **1**,**3**, respectively. Pins **1**, **3** are perpendicular to walls **5**, **7** and therefore parallel to the axis of the box B. They project into the box toward each other and their ends outside the box can be connected to any appropriate electric circuit. Within the box are placed means shown generally at **22** in FIG. 1 for reversing the electrical continuity state between pins **1**, **3**.

These means **22** comprise a first annular mass M_1, biased toward wall **7** of the box B by a spring K_1 bearing on the opposite wall **5**. The annular mass M_1 defines by its inner cylindrical surface a chamber **14**. This annular mass M_1 is positioned coaxially within the box wall **9**, its axis being parallel to pins **1**, **3**, so as to be able to move along said axis towards box wall **5**.

The means **22** for reversing the electrical continuity state also comprise a second cylindrical mass M_2 biased toward the wall **5** of the box by a spring K_2 bearing on the opposite wall **7**. Mass M_2 is positioned coaxially to mass M_1, so that it can slide within the latter in chamber **14**. To this end, sliding means are located between the two masses M_1, M_2. These sliding means include at least three longitudinal grooves **15** on the inner cylindrical surface of mass M_1, in which are received rollers or balls **13** rolling on the outer cylindrical surface of mass M_2.

In the inoperative state, i.e. when springs K_1, K_2 are relaxed, the lengths of masses M_1, M_2 and of the box are such that the end of mass M_2 facing wall **7** is partly fitted into the end of the mass M_1 facing wall **5**.

The second mass M_2 has a hole **10**, e.g. constituted by a bore, extending along the axis of each pair of the opposing pins **1**, **3**, each hole extending between the end faces of the mass M_2 that are parallel to box walls **5**, **7**. Each pin of each pair of electric contact pins **1**, **3** can slide into the hole **10** corresponding thereto during the reciprocating movements of mass M_2 in the direction of that pin. Furthermore, each hole **10** has conductive walls **11**. When the two pins of the same pair are both within the hole **10** corresponding thereto, the conductive walls **11** of the latter make it possible to establish an electric contact between these two pins. Therefore, all or part of the walls **11** of each hole **10** is covered with a conductive material deposit in order to make it possible to electrically connect the two pins **1, 3** of a pair of pins by contact with said deposit. All the walls **11** are electrically insulated from mass M_2 either because the body that constitutes mass M_2 is composed of a non-conductive material or because there is an insulator around walls **11** as shown in phantom at **23** FIG. **1**.

In the embodiment shown in FIG. **1**, only pin **1** is located in hole **10** when mass M_2 is in its initial inactive position. Thus, there is no electric contact between pins **1, 3**.

Locking means are provided between masses M_1 and M_2 to render them integral with one another during an acceleration that moves mass M_1 towards box wall **5**. These means comprise at least one spring lug **17**, located in a radial hole **18** extending from the inner surface of mass M_1, in the vicinity of its end closest to wall **5**. The locking means also include an annular groove **18** formed on the outer surface of mass M_2, in the vicinity of its end closest to wall **5**. Thus, when spring K_1 is compressed, each lug **17** is located in groove **18**.

In order to permit a separation of masses M_1, M_2 following the actuation of the isolator, the edge **19** of groove **18** closest to wall **7** can be inclined to facilitate retraction of lug **17**. The locking and unlocking of masses M_1, M_2 will be described in greater detail hereinafter relative to FIGS. *2a* and *2b*. It is obvious that any other means making it possible to keep masses M_1, M_2 attached and optionally to disengage them can be used in the isolator according to the invention.

The movements of masses M_1 and M_2 are damped, e.g. by the flow of a fluid F such as oil, between the walls of masses M_1 and M_2. When pins **1, 3** are in contact with walls **11** of the corresponding hole **10**, they prevent the flow of fluid along that hole **10**.

There follows now a description of the operation of the bidirectional accelerometric isolator according to the invention on the basis of a pair of electric contact pins **1, 3**.

In the inactive state (FIG. **1**), springs K_1, K_2 placed between masses M_1, M_2 and walls **7, 5** are relaxed. Depending upon the spring constants of springs K_1, K_2, masses M_1, M_2 are respectively in the vicinity of or against walls **7, 5**, respectively.

Electrical pin **1** supported by the first wall **5** is then in electrical contact with walls **11** of the hole **10** corresponding thereto in mass M_2. On the other hand, pin **3** supported by the second wall **7** is not in contact with walls **11** of said hole **10**.

Moreover, in this inactive state, there is no electrical contact between pins **1** and **3**, i.e. the contact is said to be open.

Under the action of a first acceleration γ_1 (FIG. *2a*) applied to the box B in a direction parallel to the axis defined by pins **1, 3** and in a direction extending from the first wall **5** to the second wall **7**, mass M_1 moves towards wall **5** in a direction opposite the direction of acceleration γ_1 towards an arming position, so that mass M_1 compresses spring K_1. The magnitude of the acceleration γ_1 necessary to displace mass M_1 towards mass M_2 is a function, to within the frictional forces, of the value of mass M_1 and of the spring constant or stiffness of spring K_1. During acceleration γ_1, mass M_2 remains engaged against wall **5**.

Moreover, due to the displacement of mass M_1 towards mass M_2, each lug **17** engages in groove **18** present in mass M_2, thus joining masses M_1 and M_2. Depending upon the positions of lugs **17** in the inner wall of mass M_1 and groove **18** in the outer wall of mass M_2, mass M_1 is locked at a greater or lesser distance from wall **5**.

As shown in FIG. *2a*, when the box B is subject to an acceleration γ_1, pins **1, 3** are still not in electrical contact because mass M_2 has not moved. That is, the end of pin **3** facing pin **1** remains free. This acceleration γ_1 only joins masses M_1 and M_2.

When a second acceleration γ_2 (FIG. *2b*) is applied to the box B in a direction parallel to the axis of pins **1, 3** and in a direction extending from the second wall **7** to the first wall **5**, i.e. in a direction which is opposite that of the first acceleration γ_1, masses M_2 and M_1 move together towards wall **7** into an actuating position. Thus, spring K_2 is compressed, while spring K_1 is relaxed. As masses M_1 and M_2 are joined together by lugs **17** in groove **18**, when mass M_1 abuts against wall **7**, it blocks the displacement of mass M_2. Any other relative position of the integral masses M_1, M_2 during acceleration γ_2 is possible. For example, for given positions of lugs **17** and/or grooves **18**, mass M_2 can abut wall **7**, thus limiting the displacement of mass M_1. In this case, a recess is made in wall **7** to receive spring K_2.

The movement of masses M_1, M_2 towards wall **7** takes place when acceleration γ_2 has a given magnitude, which is a function of masses M_1, M_2 and of the stiffness of springs K_1, K_2, bearing in mind the frictional forces in the isolator.

The displacement of mass M_2 to wall **7** enables the pin **3** to penetrate hole **10** and walls **11**, while pin **1** is still in there. Thus, an electrical contact is established between pins **1, 3** via walls **11** of said hole **10**, the contact then being said to be closed.

The length of the pins **1, 3** used makes it possible to determine the axial positions of lugs **17** and groove **18**. Thus, lugs **17** and groove **18** are disposed in such a way that pin **3** penetrates hole **10** when mass M_1, which is integral with mass M_2, abuts wall **7**.

By use of this isolator, a continuous or brief electrical contact can be established between electrical pins **1, 3** following two successive opposite accelerations γ_1, and γ_2.

A continuous contact is obtained, (1) when the acceleration γ_2 is maintained, keeping mass M_1 integral with mass M_2, or (2) following the stopping of the acceleration γ_2, i.e. in the inactive state, when masses M_1, M_2 are integral and when the stiffness of springs K_1, K_2, the value of masses M_1, M_2 and the lengths of pins **1, 3** make it possible to maintain an electrical contact between pins **1, 3** and walls **13** of hole **10**, or by locking either mass M_1, or (3) mass M_2 to wall **7**, masses M_1 and M_2 being integral.

A brief contact is obtained by unlocking masses M_1, M_2 following successive acceleration γ_1 and γ_2, i.e. after establishing the electrical contact. Therefore, unlocking means are associated with the isolator according to the invention.

An example of the unlocking means is shown in FIGS. **1** to *2b*. More particularly, groove **18** has an inclined edge **19**, so that said groove **18** offers a larger opening on the outer wall of mass M_2. Thus, mass M_1 is integral with mass M_2 until the latter, as a result of the stiffness of its spring K_2, pushes back by means of its inclined edge **19** the lugs **17**. The lugs **17** retract, releasing mass M_2 from mass M_1 and spring K_2 relaxes, moving mass M_2 toward wall **5**. Now, pin **3** is no longer in electrical contact with walls **11** of the hole **10**, so that the contact is again open. During further successive accelerations γ_1 and γ_2, the isolator can reestablish electrical contact between pins **1, 3**.

This example is not limitative and other unlocking means can be envisaged, particularly by the use of an electromagnet, whose magnetic core forces back mass M_2 towards the first wall **5**, following two successive accelerations γ_1 and γ_2.

In FIG. **1**, three pairs of pins **1, 3** are shown, one pair by continuous lines and the two other pairs by dot-dash lines. The number of pairs of pins used depends on the use of the isolator according to the invention. The isolator can have between one and several pairs of pins arranged parallel to one another and at a spacing which is a function of their use.

FIG. **1** shows one hole **10** per pair of pins, but it is obvious that mass M_2 can have holes **10** which are common to several pairs of pins located in the same plane, as a function of the use of the isolator.

Masses M_1 and M_2 are preferably cylindrical, but other shapes, and in particular parallelepipedic shapes, can be envisaged. Each of the masses M_1, M_2 can also be constituted by several masses which are assembled together and in particular two masses, the spacing between said two masses respectively forming chamber **14** and hole **10**. Furthermore, several springs K_1, K_2 can be used in the isolator according to the invention.

In addition, box wall **9** can completely or partly surround the means for reversing the electrical continuity state between the pins. Moreover, locking means for masses M_1, M_2 different from those described in FIGS. **1** to **2*b*** can be envisaged without passing beyond the scope of the invention.

The above description has been given with reference to an embodiment of the isolator according to the invention with open contact in the inactive state and closed contact after two successive accelerations γ_1 and γ_2, but the reverse is also possible. Thus, by modifying the lengths of pins **1** and **3**, the isolator can be in closed contact in the inactive state and in open contact following two successive accelerations γ_1 and γ_2. For this purpose, use is made of a longer pin **3** and a shorter pin **1** than in the embodiment described relative to FIGS. **1** to **2*b***, so that pins **1** and **3** are in contact with walls **11** of hole **10** in the inactive state and pin **1** is no longer in contact with walls **11** of said hole **10** after two successive accelerations γ_1, γ_2. In the same way, with this type of isolator, it is possible to obtain a continuous or brief contact.

The isolator according to the invention can have reduced overall dimensions with a diameter of approximately 30 mm and a length of approximately 70 mm. It is normally able to operate under thermal conditions ranging between approximately −25° C. and +70° C., in a mechanical environment with static accelerations and white noise. However, it is insensitive to "aggressions", so that it does not function in an accidental environment, such as one with a high shock level and fires.

The isolator according to the invention makes it possible to establish between two electric pins, respectively in the case of a continuous or brief contact, a d.c. current of approximately 10 A or a pulse-type current of approximately 3000 A for 2 μs under a voltage between 0 and 4 kV.

The two successive acceleration γ_1 and γ_2 of opposite directions respectively correspond both to an acceleration followed by a deceleration and to a deceleration followed by an acceleration.

The isolator according to the invention has very wide-ranging applications, appropriate calculations of the value of the masses, the stiffness of the springs and the lengths of the electric pins making it possible to adapt the isolator to a given problem, even in a constraining environment.

What is claimed is:

1. An accelometric isolator comprising

A. an enclosure having an axis;

B. at least one pair of contact means supported within said enclosure at locations spaced apart along said axis;

C. a pair of masses positioned in said enclosure for movements from respective inactive positions therein in opposite directions along said axis in response to oppositely directed accelerations of said enclosure parallel to said axis;

D. coacting locking means on said masses for locking said masses together when said masses assume a selected relative position within said enclosure during acceleration of said enclosure parallel to said axis in one direction; and

E. electrically conductive means on one of said masses which changes the electrical conductivity state between said contact means when the locked-together masses are moved in said one direction during an acceleration of said enclosure parallel to said axis in the opposite direction.

2. The isolator defined in claim **1** and further including means for biasing said masses toward their respective inactive positions.

3. The isolator defined in claim **1** wherein

A. said enclosure includes end walls spaced apart at opposite ends of said axis;

B. each pair of electrically isolated contact means comprise conductive pins mounted to said end walls and extending toward one another parallel to said axis; and

C. said one of said masses has an axial passage which slidably receives each pair of pins, said passage having an electrically conductive surface which constitutes said conductive means.

4. The isolator defined in claim **1** wherein

A. said other of said masses is an annular body that receives said one of said masses; and

B. said locking means include

1. at least one spring-loaded lug projecting from one mass toward the other mass, and at least one lug-receiving means in the other mass which receive said at least one lug when said masses have said selected relative position in said enclosure.

5. The isolator defined in claim **4**

A. further including means for biasing at least one of said masses toward its inactive position; and

B. wherein one of said at least one lug and receiving means has an inclined edge to facilitate unlocking of said masses by said biasing means when said enclosure is not being accelerated.

6. The isolator defined in claim **1**

A. wherein said masses have opposing surfaces which extend parallel to said axis; and

B. further including bearing means between said opposing surfaces to facilitate relative motion of said surfaces.

7. The isolator defined in claim 1

A. wherein said enclosure is substantially fluid tight; and

B. further including a fluid in said enclosure for damping movements of said masses within said enclosure.

8. The isolator defined in claim 1 wherein

A. said enclosure supports several pairs of contact means, each such pair comprising a pair of collinear pins projecting toward one another parallel to said axis; and

B. said other of said masses has an axial passage aligned with each pair of pins for slidably receiving same, each said passage having an electrically conductive surface that constitutes said conductive means.

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